Return to Flight

Reinforced Carbon-Carbon

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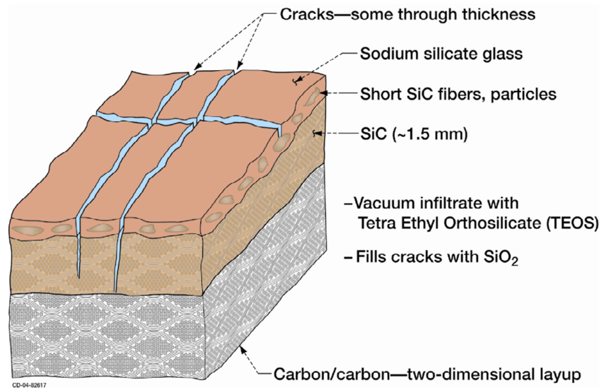
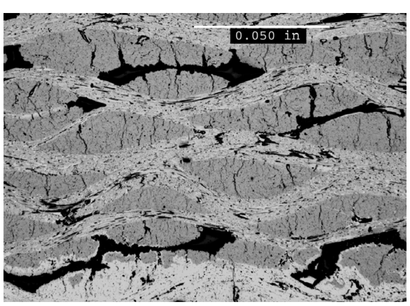
The requirements for reusability, weight, thermal protection, and structural performance of the space shuttle leading edge imposes significant engineering challenges to the existing fleet of orbiters. Reinforced carbon-carbon (RCC) is a critical material for application on the wing leading edge and nose cap, where maximum temperatures are reached on reentry.



Schematic of reinforced carbon-carbon material used for the shuttle orbiter.

The existing leading-edge system is a prime, reliable protection scheme for the vehicle, as the leading-edge structure of the vehicle comprises single-plate RCC composite panels with a wall thickness of less than 6.5 millimeters. The figure to the right is an illustration of the as-fabricated structure of the RCC material. The primary factor limiting mission life is oxidation of the carbon composite substrate leading to loss of strength. Return-to-flight activities at NASA Glenn Research Center (GRC) are studying the RCC material to gain a deeper understanding of how the material degrades with each mission cycle and the impact on safe mission limits.

Leading-edge material with actual exposure up to 30 missions is now available to assess actual strength reduction through testing, nondestructive evaluation, and microstructural characterization using current analytical techniques. A detailed microstructural examination of as-fabricated RCC is an essential part of this task to understand the baseline material. State-of-the art facilities at GRC are key to the success of this effort. These facilities include the Analytical Services and Metallography laboratories. Samples were obtained in various stages of the process and examined with optical and electron optical techniques. Quantitative image analysis was used to determine porosity in polished cross sections. Gas adsorption techniques were used to measure internal surface areas.



Polished cross section showing pores in substrate.

The microstructure was found to show large variations in several areas including porosity, coating morphology, and crack density. The figure to the left shows a region of the carbon-carbon substrate. The origin of these pores can be traced to processing steps. Many of the voids are due to shrinkage of the resin material during pyrolysis.

Establishing a well-documented database for the as-fabricated material will assist in safely assessing aging effects from high-temperature/environmental exposure of the flown and furnace or arcjet conditioned material.